I-I Lin (林依依)

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1985-1989: BSc, Dept. of Atm. Sciences, NTU

1989-1995: PhD in Remote Sensing, Univ. of Cambridge, UK

1995-1999: Centre for Remote Imaging, Sensing and Processing, National University of Singapore, Singapore

2000-July 2004: National Center for Ocean Research, NTU/NSC

2004-> : Dept. of Atmospheric Sciences, NTU

Interests: *Typhoon – Ocean Interaction*
Air-sea Biogeochemical Interaction & Carbon Cycle
Remote Sensing

Synergy of Multi-Advanced Remote Sensing for Atmosphere-Ocean InTeraction Research (SMART)

What is the long-term variability of SST and subsurface condition in this MDR (Main Development Region)?

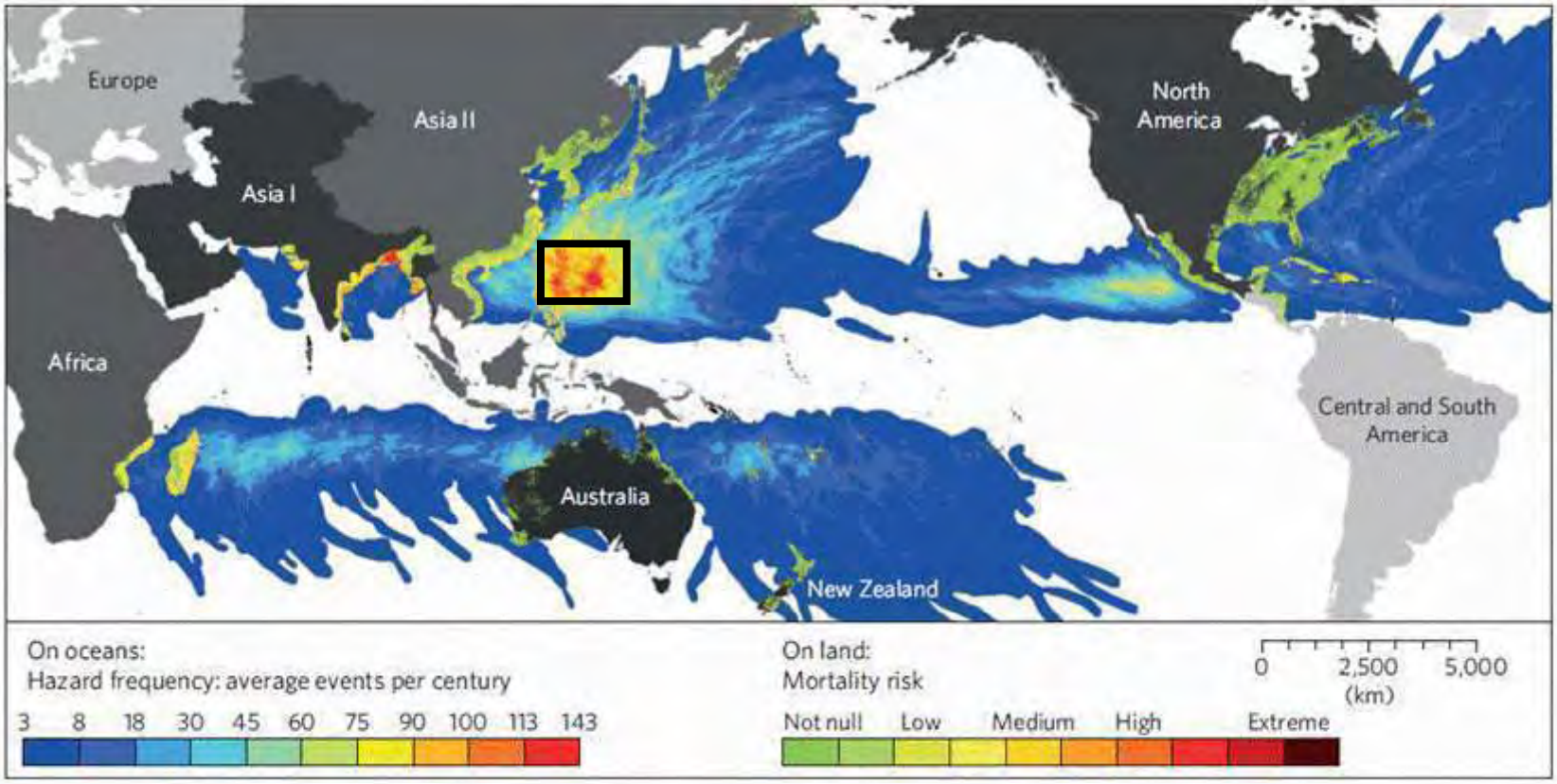
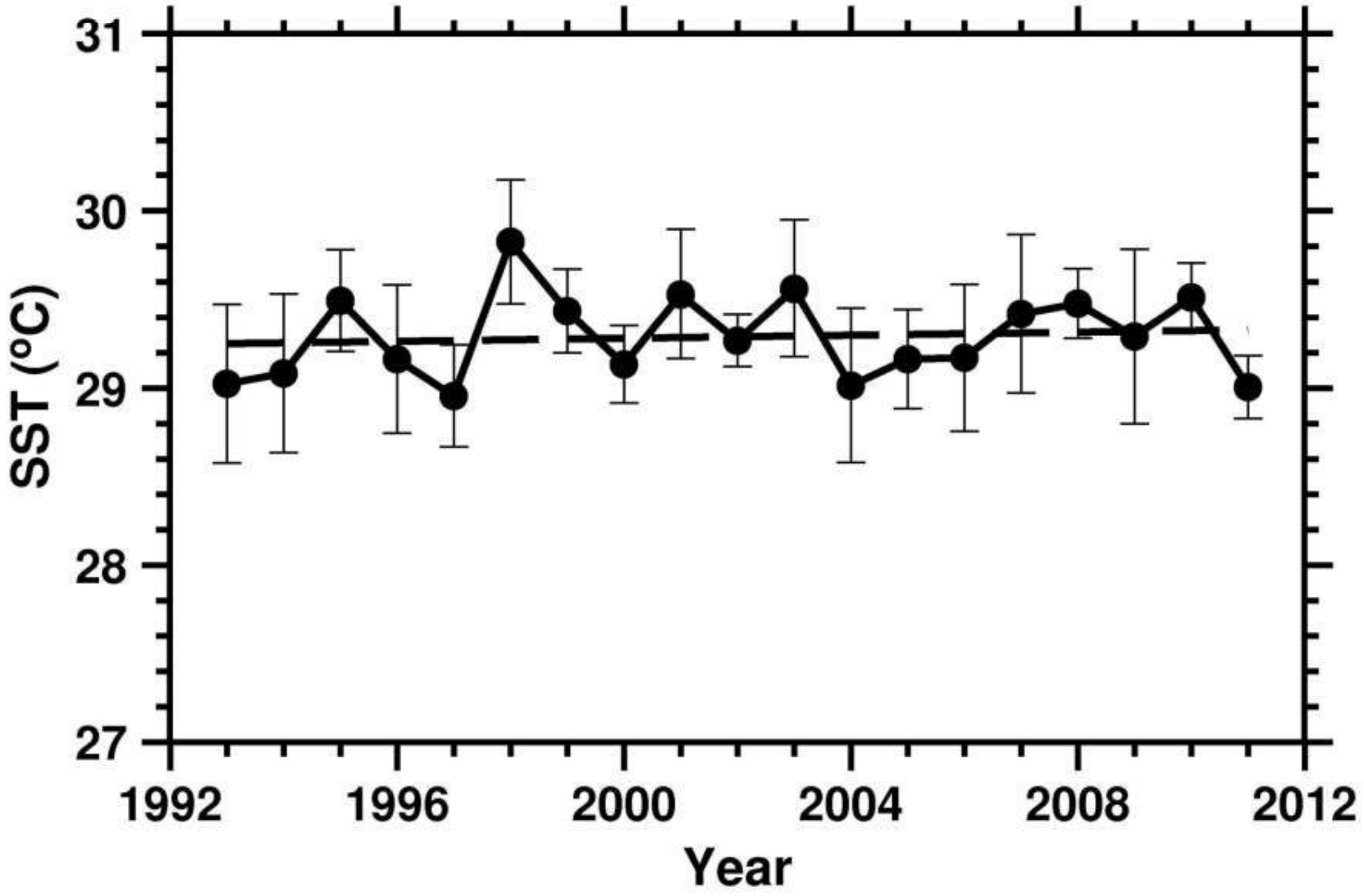
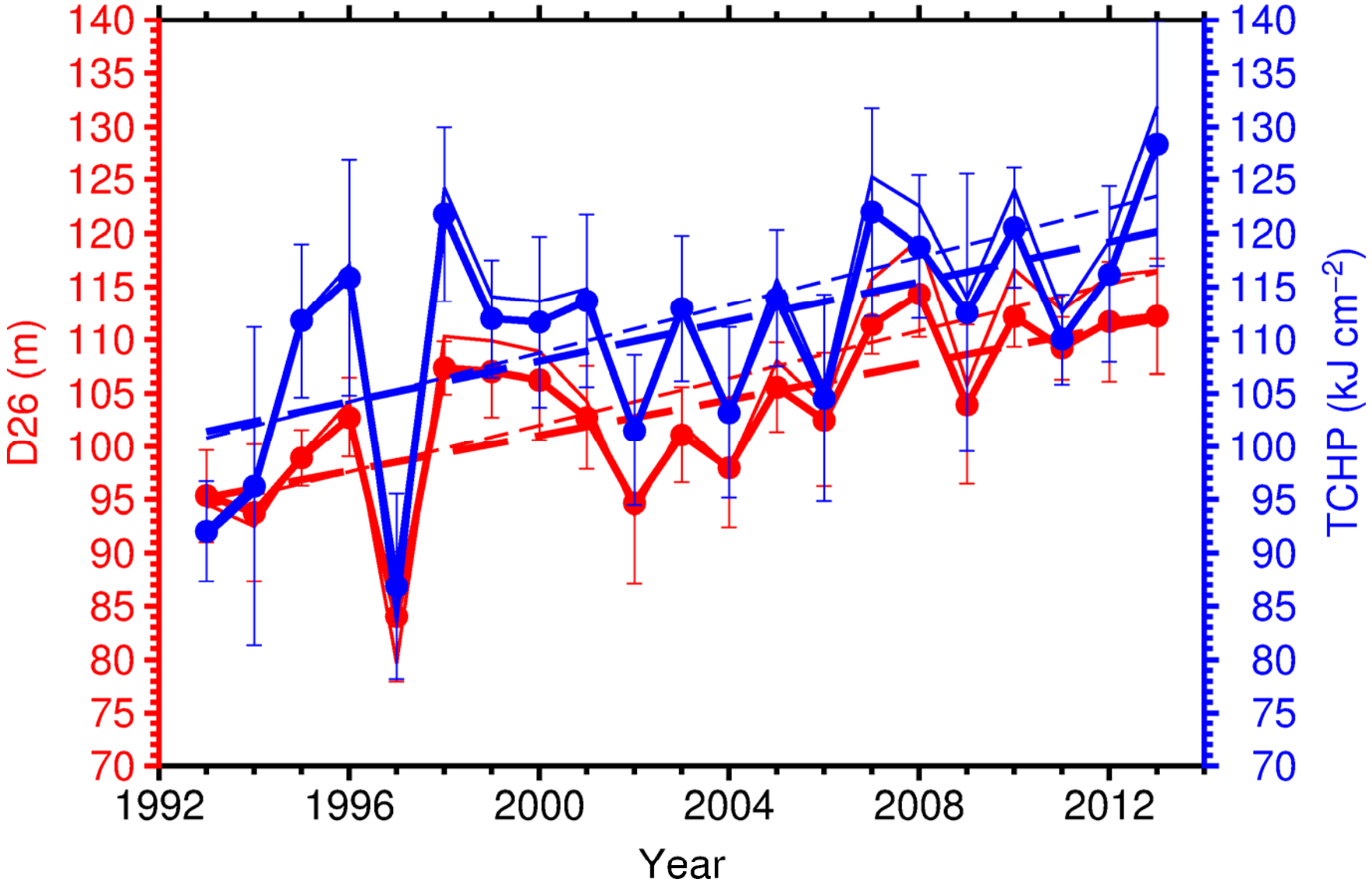


Figure 1 | Map showing distribution of hazard frequency and mortality risk from TCs for the year 2010. Estimates are applied to all pixels on a geographic grid. Mortality risk is categorized from low to extreme.

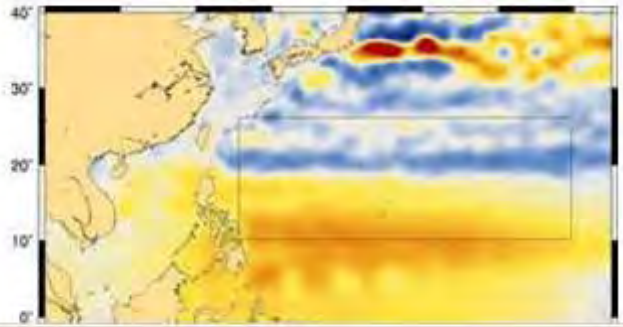
Peduzzi et al. *Nat. C.C.* 2012

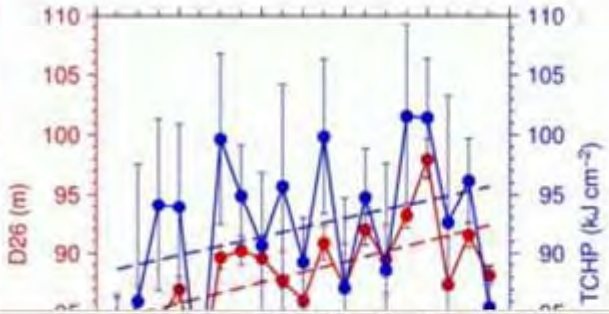

31
30
29
28
27
SST (°C)
1992
1996
2000
2004
2008
2012
Year

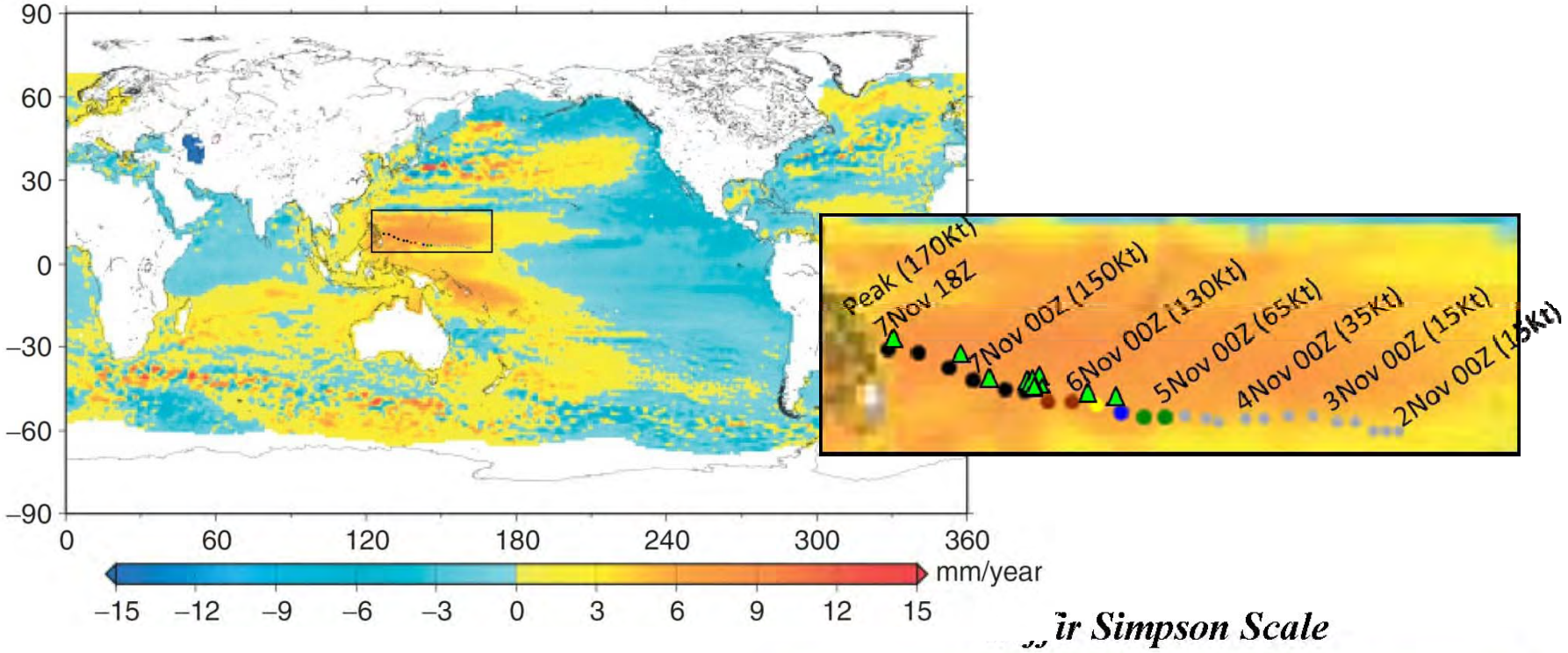

140
135
130
125
120
115
110
105
100
95
90
85
80
75
70
D26 (m)
TCHP (kJ cm^{-2})
1992
1996
2000
2004
2008
2012
Year

20 years of altimetry for typhoons

Image of the Month - August 2013



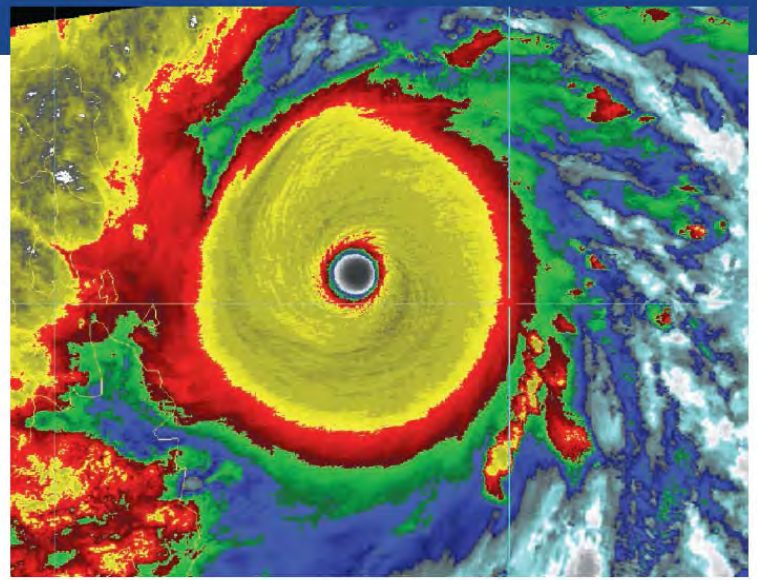




...ir Simpson Scale

Fatalities: 6,230 and 1,785 missing
Damage $US1.5 billion

Category	Winds (knots)	
TD	< 34	
TS	34-63	
1	64-82	*19 kts*
2 (Sandy 2012)	83-95	*13 kts*
3	96-113	
4	114-135	*22 kts*
5	>135	
Cat 6 ? Megi 2010 Haiyan 2013	160 (170) kts	*25 (35) kts*



Feeding the monster. Unusually warm Pacific waters supercharged Haiyan.

CLIMATOLOGY

Clues to Supertyphoon's Ferocity Found in the Western Pacific

Tropical storm watchers agree that Haiyan was probably the strongest typhoon to make landfall when it slammed into the Philippines on 8 November, packing winds of up to 314 kilometers per hour. What gave Haiyan, which killed thousands and displaced millions, its deadly wallop?

Researchers think they have at least a partial answer to that question: unusually warm subsurface Pacific waters east of the Philippines. A related phenomenon—rising sea levels in the western Pacific—likely abetted Haiyan's devastating storm surge, which caused more deaths than the winds themselves.

Typhoons draw heat from the ocean for the energy that generates their winds. Typically, as a storm's winds increase, they stir up deeper, cooler ocean waters that temper its strength. This cooling effect "is nature's brake to stop typhoons from intensifying," says I-I Lin, a specialist in typhoon-ocean interactions at National Taiwan University in Taipei.

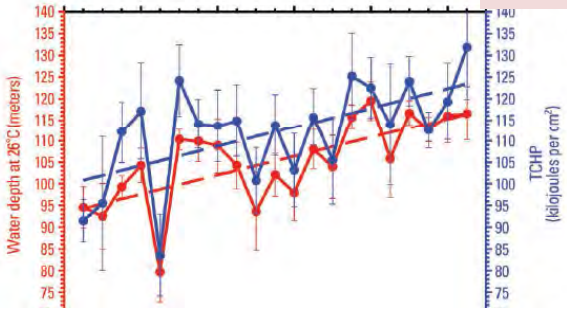
Drawing on data from satellite observations and Argo floats—

have documented a steady 2-decade rise in subsurface temperatures in the western North Pacific and a bulging warm water layer. The warmer and thicker that subsurface layer, the more heat is available to feed a storm. Oceanographers use a measure called the Tropical Cyclone Heat Potential (TCHP) to quantify the heat reservoir. Lin and colleague Iam-Fei Pun reported online on 3 September in *Geophysical Research Letters* that the TCHP where most cyclones develop in the western North Pacific has increased 10% since the early 1990s (see graph). While surface waters along Haiyan's path were only slightly warmer than normal, waters down to 100 meters were 3° warmer than the historical average. So as Haiyan churned up western Pacific waters, it drew more wind-intensifying heat, Lin says.

Other factors contributed to Haiyan's intensity. "The genesis location was very important," says Il-Ju Moon, a marine meteorologist at Jeju National University in South Korea who studies how ocean heat influences typhoons. Haiyan originated around 5° latitude north of the equator and was at about 10° when it hit land. "The ocean heat content is very high in that region," Moon says. And starting more than 3000 kilometers east of the Philippines gave Haiyan plenty of open water over which to strengthen.

Haiyan was a speed demon as well. "It was flying over the water" at 32 kilometers per hour, Lin says, nearly twice as fast as most typhoons travel. "Why it moved so fast is unknown," she adds. Researchers speculate that a fast-moving storm passes by before its churn pulls energy-sapping deeper, cooler water to the surface. In any case, "the warmer the subsurface layer, the faster the moving speed, the smaller the cooling effect," Lin says. "It's like a car without a brake, only an accelerator."

The warm bulge in the western North Pacific is the result of stronger easterly trade winds. This phenomenon also aggravated Haiyan's storm surge. In addition to blowing

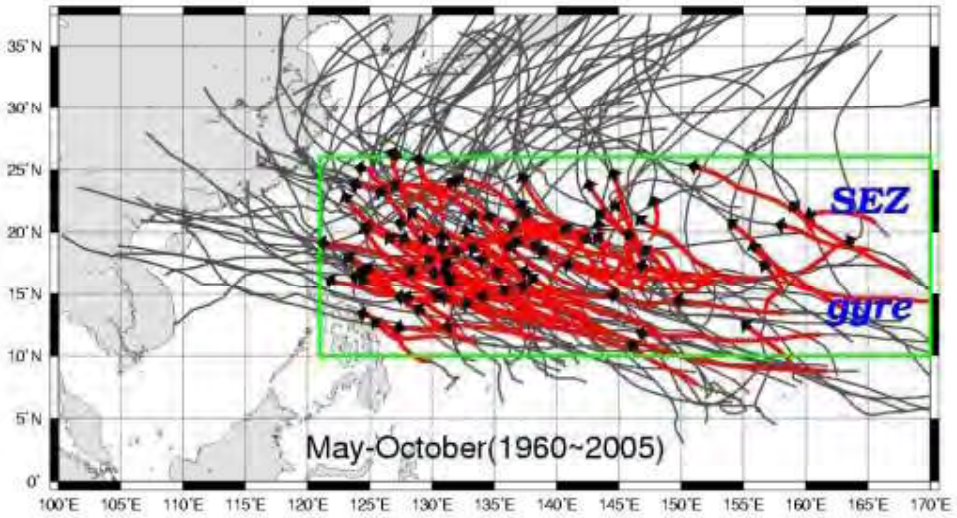


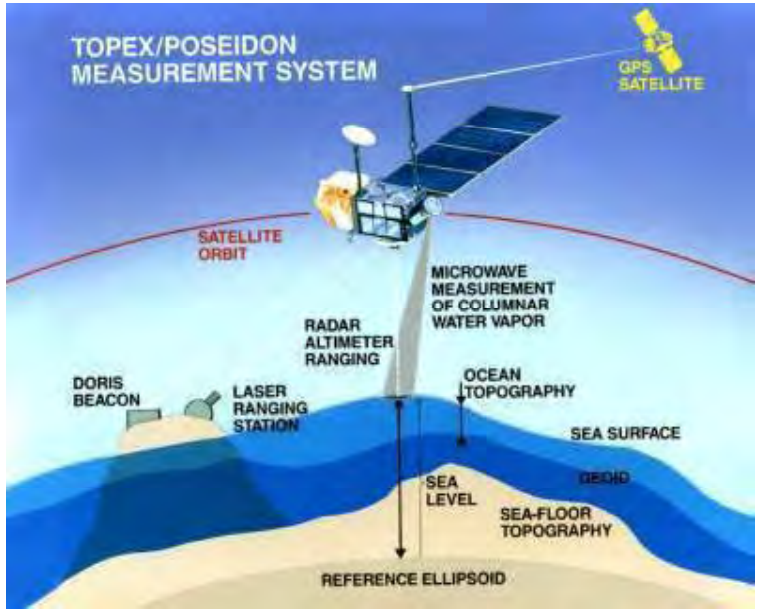
BOTTOM: JOHN KNAFF, NOAA/NESDIS/RAMMB, CSU/CIRA; I-I LIN

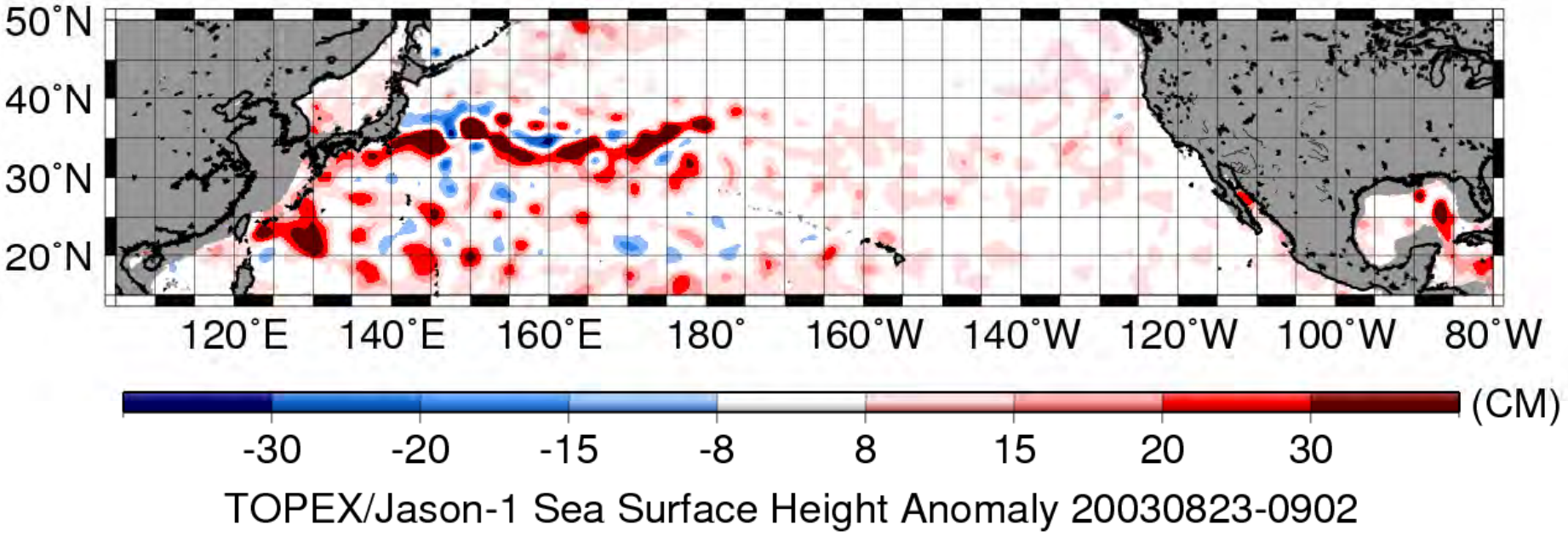
Science
Vol. 342 no. 6162 p. 1027
29 Nov., 2013

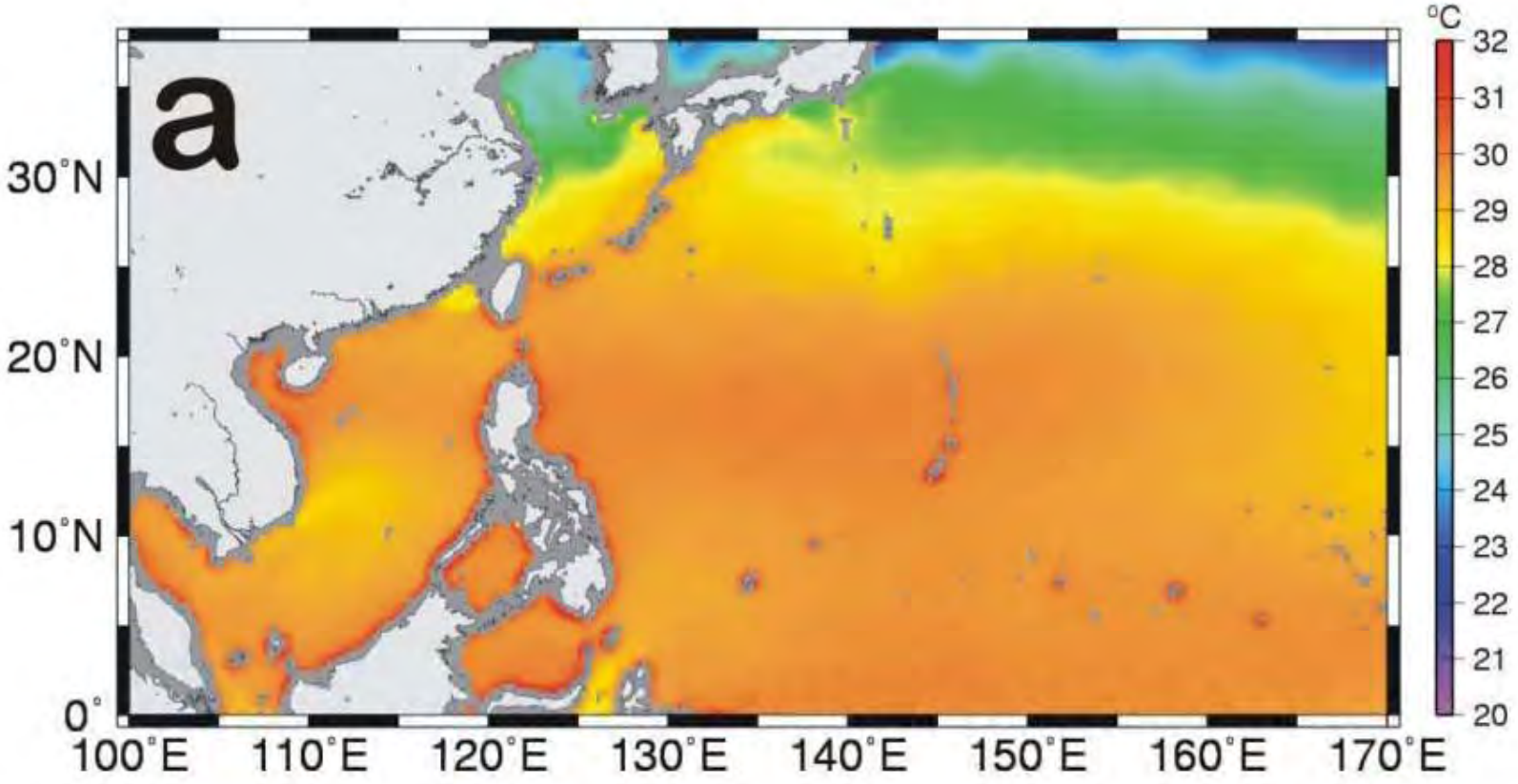
to the flood and inundation problems" in the Philippines, he says.

While many observers blame Haiyan's destructive power on climate change, tropical storm experts say there is little hard evidence of a link. "It is possibly natural variability," Lin says. Nor is it certain that the western Pacific has become a supertyphoon breeding ground. Although warmer subsurface


35°N
30°N
25°N
20°N
15°N
10°N
5°N
0°
100°E 105°E 110°E 115°E 120°E 125°E 130°E 135°E 140°E 145°E 150°E 155°E 160°E 165°E 170°E
SEZ
gyre
May-October(1960~2005)


TOPEX/POSEIDON
MEASUREMENT SYSTEM
GPS
SATELLITE
SATELLITE
ORBIT
MICROWAVE
MEASUREMENT
OF COLUMNAR
WATER VAPOR
RADAR
ALTIMETER
RANGING
DORIS
BEACON
LASER
RANGING
STATION
OCEAN
TOPOGRAPHY
SEA SURFACE
GEOID
SEA
LEVEL
SEA-FLOOR
TOPOGRAPHY
REFERENCE ELLIPSOID


50°N
40°N
30°N
20°N
120°E 140°E 160°E 180° 160°W 140°W 120°W 100°W 80°W
(CM)
-30 -20 -15 -8 8 15 20 30
TOPEX/Jason-1 Sea Surface Height Anomaly 20030823-0902


a
30°N
20°N
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0°
100°E
110°E
120°E
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160°E
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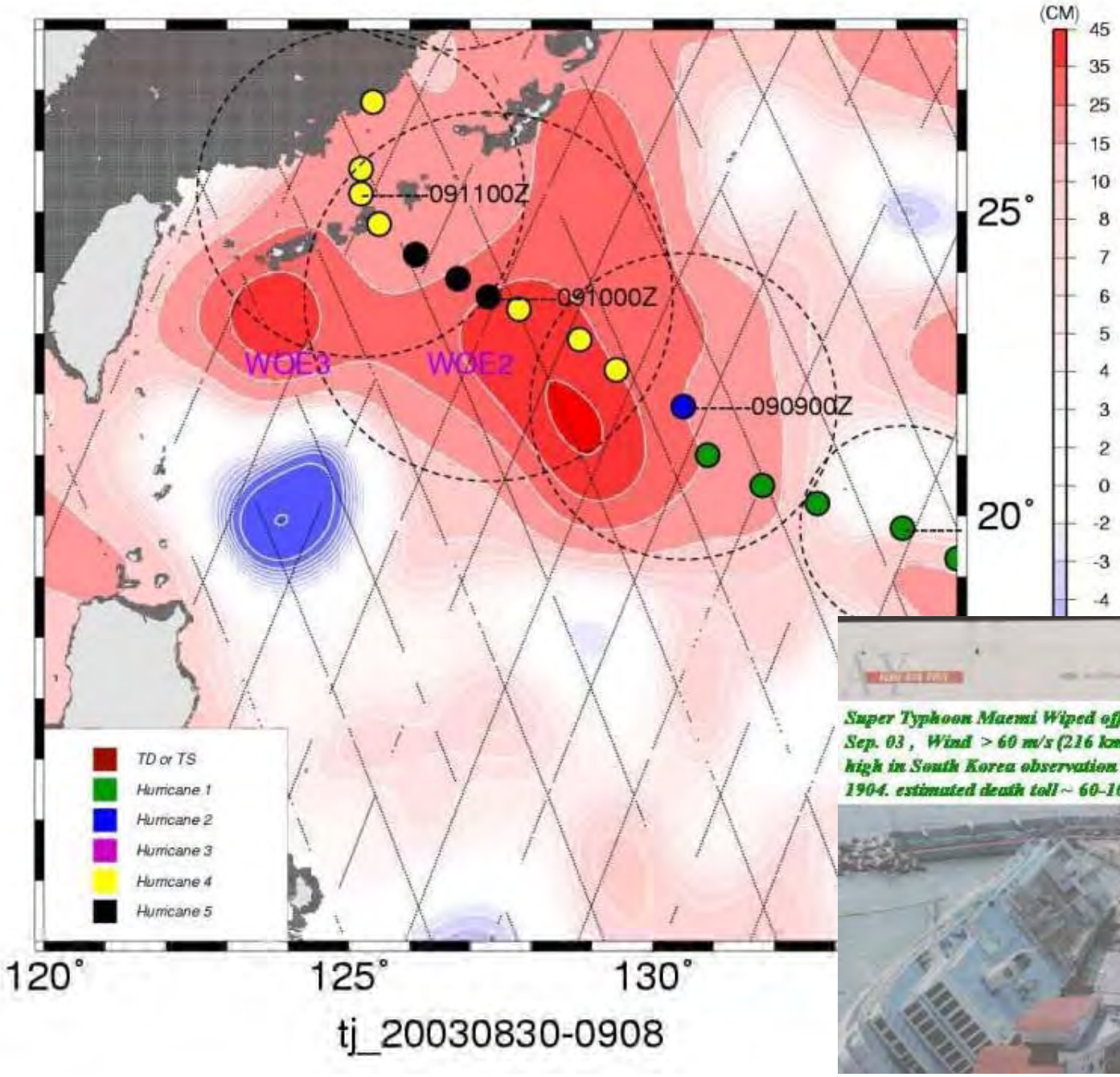
Lin et al. MWR 2005



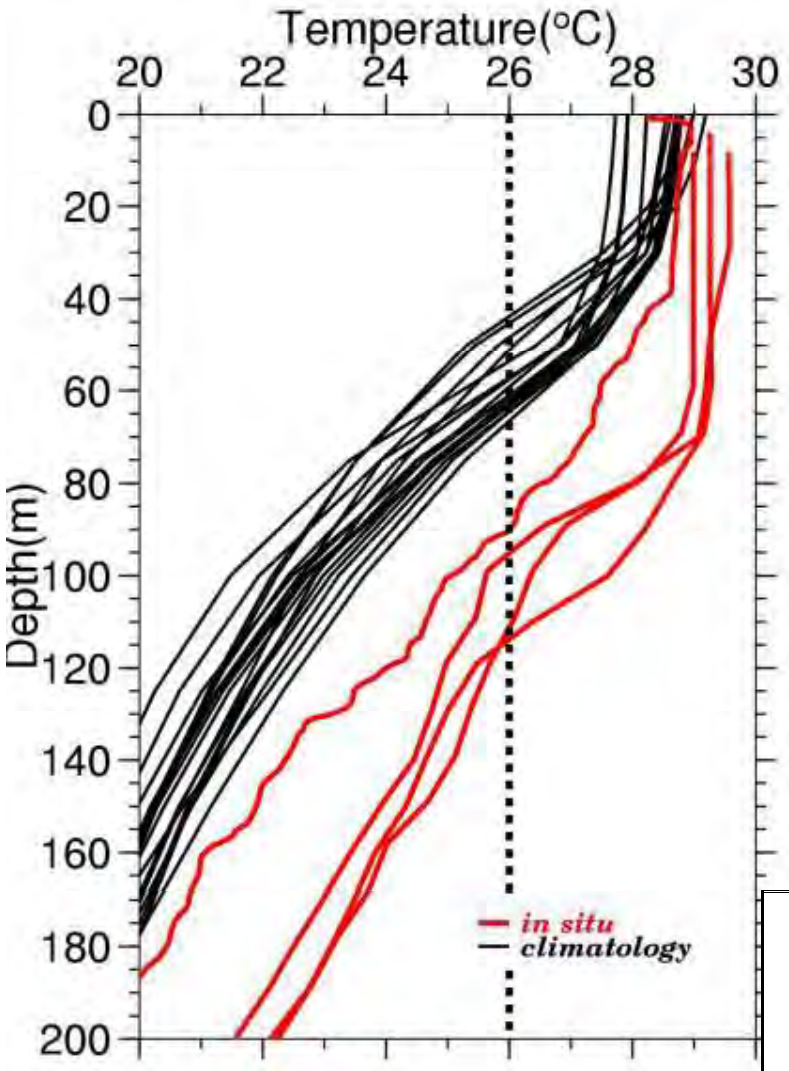
The most intense cyclone on earth in 2003

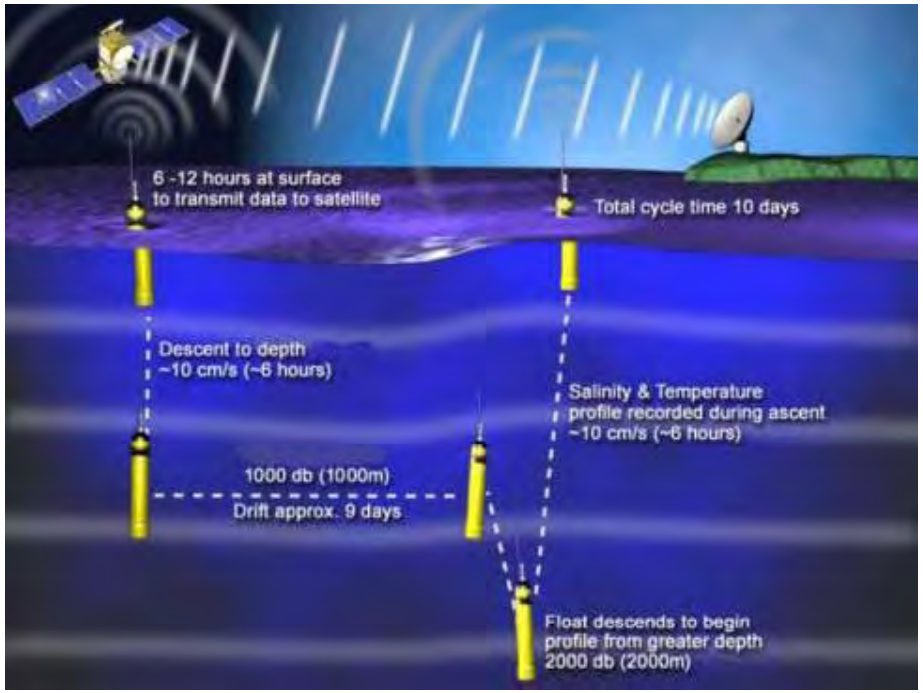
- *Maemi 79 m*

Isabel 74 m/s

- *The most inte*

super typhoon globally

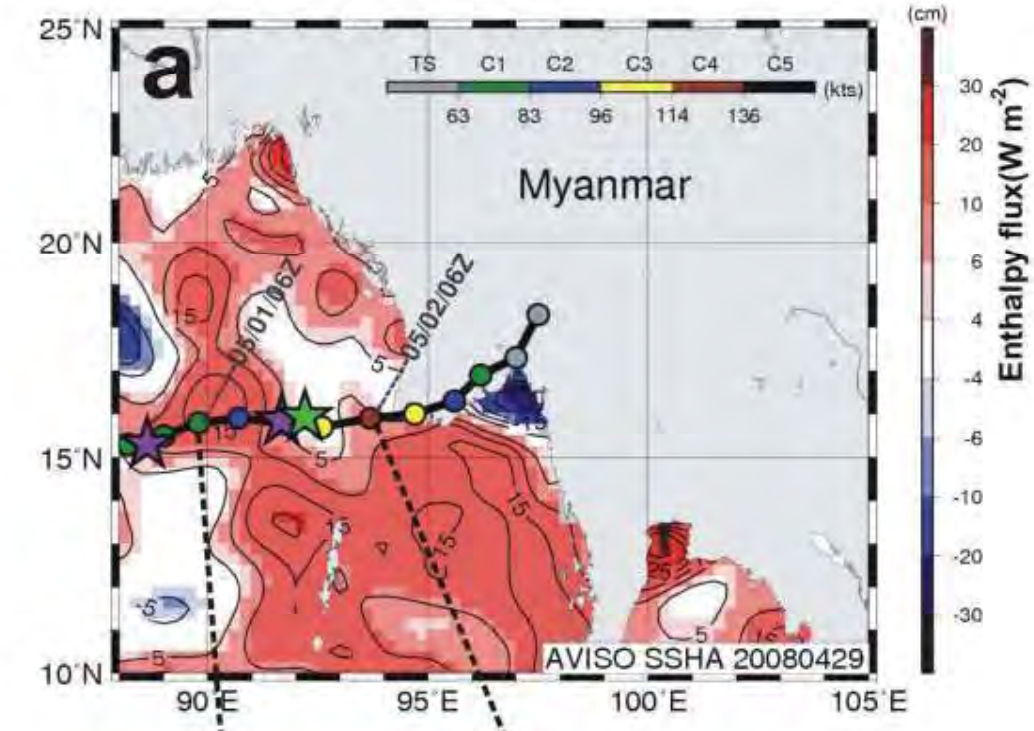


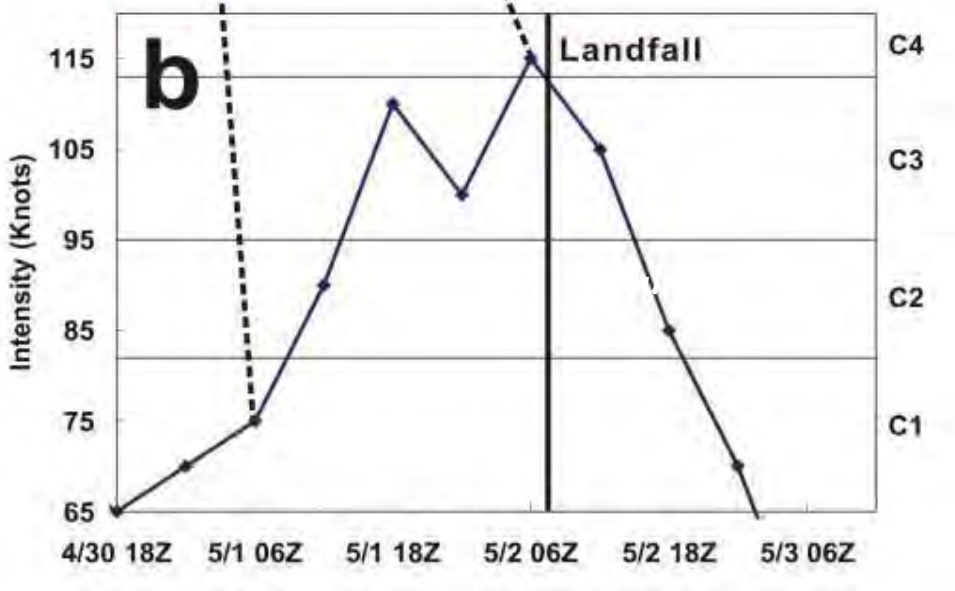


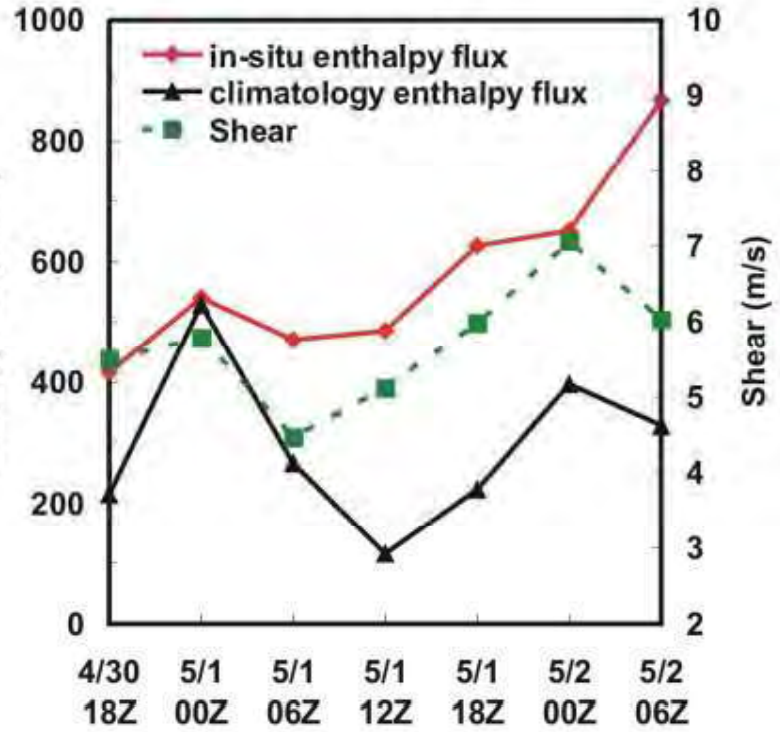
Lin et al. MWR 2008

In situ profiles	*In situ* D26 (m)	D26 (m) Climatology	Deepening / shoaling of D26 (m)	% of deepening/ shoaling w.r.t. climatology
Saomai (2000)	88	58	+30	+52%
Maemi_1	129	63	+66	+105%
Maemi_2	96	63	+33	+52%
Maon	109	63	+46	+73%
Average	106	62	+44	+69%

Killer cyclone Nargis (2008)





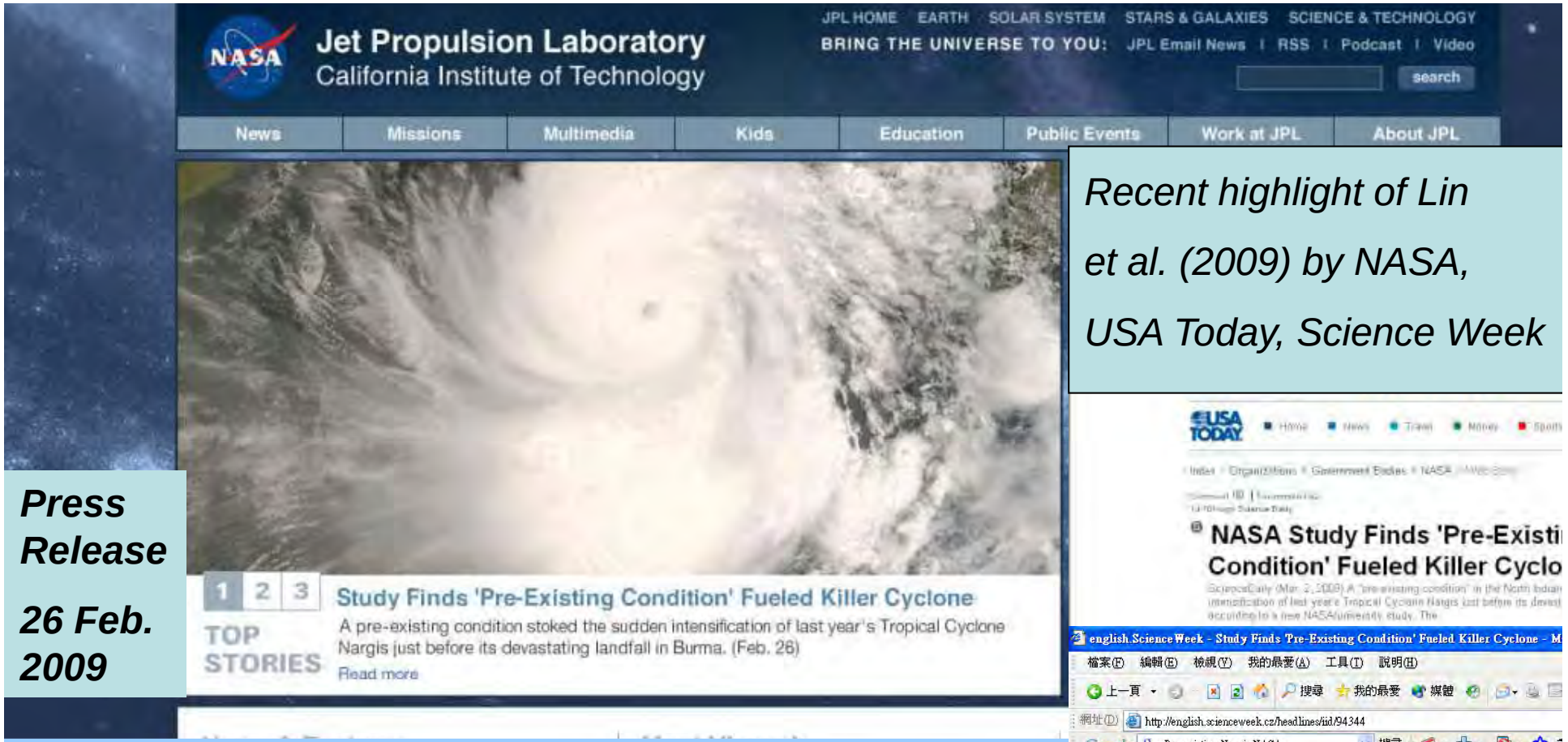


Catastrophic event (> 130,000 death toll):

RI took place just prior to landfall

Lin et al.

GRL 2009



Press Release

26 Feb. 2009

Recent highlight of Lin et al. (2009) by NASA, USA Today, Science Week

PASADENA, Calif. - A "pre-existing condition" in the North Indian Ocean stoked the sudden
Cyclone Nargis just before its devastating landfall in Burma, according to a new NASA/unive
worst natural disaster ever and one of the deadliest cyclones of all time.

Scientists at the National Taiwan University, Taipei; and NASA's Jet Propulsion Laboratory, P
altimeters, measurements of ocean depth and temperature and an ocean model to analyze
of the catastrophic storm. Nargis intensified from a relatively weak category 1 storm to a cat
before making landfall on May 2, 2008.

Lead author I-I Lin of National Taiwan University and her team found the ocean conditions N
recipe for disaster. Cyclones thrive on warm layers of ocean water that are at least 26 degre
they traverse the ocean, they typically draw deep, cold water up to the ocean surface, a proc
and even weakens them as they evolve. However, Nargis passed over a pre-existing warm